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THE TREATMENT OF ROOT DISEASES.

BY

A. C. TUNSTALL.

Few planters realise even yet the amount of damage done by root diseases. It can be safely said that not one tea garden is free from some form of root disease. This is not surprising when we consider the amount of root disease producing fungi present in the jungle. Most of the North-East Indian tea gardens were planted out on cleared jungle land. It is quite impossible to remove all the dead wood from the soil of newly opened forest land and sooner or later the fungus diseases present in the dead wood attack some of the tea bushes. In the case of some diseases the power of infection may be retained for many years on dead wood. For instance, at Tocklai an outbreak of brown root disease (*Hymenochaete noxia=Fomes lamaoensis*) was traced to a piece of Nahor (*Mesua ferea*) root which must have been buried in the soil 4 feet deep for at least fourteen years.

It is obvious therefore that outbreaks of root disease must be expected and a constant watch must be maintained to check such outbreaks as soon as they occur.

It has often been suggested that only certain jungle trees are attacked by the fungi which cause root disease in tea and if a list of these trees were prepared special care could be taken to remove their roots from new clearances before planting. This, at first sight, appears to be a very reasonable suggestion but when the attempt was made to work it out in practice it was found impracticable. Although certain trees are more liable to be attacked, when alive, than others : the others are just as liable to attack when dead. It is therefore necessary to dig out all the tree roots if root disease is to be avoided. This is a practical impossibility so that, although much can be done to avoid it by careful clearing, some root disease is bound to occur sooner or

later. The more dead wood is left in a new clearance the more root disease is likely to attack it. Even sawn timber, such as the planks of bridges, fence posts, etc., are liable to start root disease.

The neglect of a single outbreak of root disease may in time result in the loss of hundreds of bushes and it is of the utmost importance to act promptly.

The first thing to do is to remove the dead bush. If only one bush has died special care should be taken at the time of removal to trace out its various roots. In many cases only one lateral is badly diseased and if this is traced it frequently happens that the centre of infection is found and may be removed. If all the diseased roots are carefully traced out some of them will often be found to be in contact with those of neighbouring bushes. All the bushes whose roots are found to be in contact with diseased ones should be dug out also. All the little pieces of root should be placed in a basket as they are removed from the soil. No wood should be allowed to remain in the soil. This wood should be promptly burned. If this work is done carefully the outbreak will be satisfactorily checked and there is no need for further treatment. The vacancies may be filled in whenever convenient.

It is frequently suggested that some chemical treatment should be applied to the soil. This is in most cases unnecessary and in any case no chemical applications avoid the necessity of removing the dead wood. That must be done and the success of root disease treatment depends on the thoroughness with which it is done. It is fairly obvious that no chemicals applied to the soil are likely to kill a fungus present inside wood. It may under exceptionally favourable conditions kill the fungus on the surface of the wood. The root disease fungi are mostly inside wood, not free in the soil, and in consequence it is much better to carry out the removal of the wood thoroughly than to rely on the application of a patent medicine to the soil. If the soil is in an unsatisfactory condition manures suitable to the soil requirements should be applied. Some root diseases only thrive

on plants growing in soil which is insufficiently aerated. Lime is often useful in these cases because it tends to flocculate the soil and thus helps to improve drainage. It is also supposed to aid bacteria in the breaking down of woody matter. In a few cases, *e.g., Rosellinia Sp.*, it is known to have a direct effect on the fungi concerned. Its efficiency in this respect has been overated in the past. In a number of instances its application has certainly checked some root diseases but very frequently its effect has not been noticeable. In this connection it is interesting to note that some planters hold the curious idea that lime should be sprinkled on the bottoms of trenches cut to isolate diseased roots. This lime would do no harm but it is difficult to see what good it could possibly do. The isolation of the roots of a diseased bush from those of its neighbours by means of a trench cut deep enough is very useful in cases where the dead bushes cannot be removed at once but it generally involves as much labour as the removal of the dead bush. It is only recommended therefore in the case of comparatively large areas of dead bushes. It should then be dug so as to enclose two complete lines of apparently healthy bushes and when time permits all the bushes within the trench, dead, dying and apparently healthy ones should be dug right out every bit of wood being removed from the soil and burned. It is generally more satisfactory to take out a complete rectangle as it is easier to supervise replanting.

To summarise—The only satisfactory way to deal with root disease is the complete removal of the diseased material. No chemical treatment will ever obviate this necessity. Promptness in the removal of the diseased bushes and all dead wood in their vicinity is essential.

CUT-BACK TEA.

BY

H. R. Cooper.

Any form of heavy or medium pruning must be followed by loss of crop for at least several years. Unless, therefore, the bush after this period is permanently and greatly improved by the cutting back, the operation has only entailed increased expenditure and decreased returns.

In a large number of cases in practice, cutting back, so far from having effected any improvement in the bushes, has rendered them much worse than they were before. Unless it is remarkably vigorous any stem cut when an inch or more in thickness throws a new shoot from some distance below the cut. The wood above the new shoot dies, leaving a snag which very soon becomes diseased and starts the rotting of the remainder of the stem. Even when the snag is removed within a year or two after cutting, the cut through dry wood will not callus and disease may enter through the wound.

Collar pruning is not necessarily a safeguard against introduction of disease after cutting back. Collar pruning means a cut through the thickest and oldest part of the bush, where it is most difficult for the wound to heal over, and if a disease is introduced at the collar it cannot afterwards be removed by pruning.

Cutting back is too often performed as a matter of routine, or worse, as the only method of restoring a weak bush to health. Many areas of tea which are considered to require cutting back on account of weakness or decreasing yield are really in need of nursing and feeding because they are suffering from the results of their last attack of cutting back.

Tea is often cut down because it is weak, and nothing done to remove the cause of the weakness. As soon as the production of dark green vigorous shoots following the stimulus of

cutting has ceased, the original cause of weakness again asserts itself with increased force on a bush further weakened by cutting. In bad cases, the stimulus of cutting fails to produce even the first vigorous shoots. The worst tea one sees is usually tea which, being originally poor, has been further weakened by cutting, and has soon afterwards been cut down again.

Cutting down, by itself can only effect any improvement either because disease of the stems is thus removed, or because good growth is given after the cutting. In the latter and more general case, greater improvement, with less loss of crop, could have been produced by allowing good growth by sparing plucking, without cutting down, particularly if cultivation and manuring were improved also.

Cutting down, then, has no virtue in itself and introduces causes of danger to the bush. It should therefore be avoided when possible. The cause of mere weakness or of decreasing yield should be traced, and the cause removed ; while the presence of diseased branches should be treated by the clean removal of the diseased branches only, while, again, the conditions which render the bush susceptible to the particular disease should also be improved.

There are however cases when one step towards the simplest method of restoring a section to full yield is some degree of heavy pruning. Such cases are most commonly met with on old tea, generally because the removal of single branches as they became diseased, and the clean removal of snags which introduce disease, have not been properly dealt with during the ordinary routine of pruning, while preventive measures such as spraying and correct manuring have probably been neglected, also.

Considerations Regarding Severity of Cutting Back.

Any pruning which still leaves diseased wood in the bushes can only effect a temporary improvement in vigour at best. It is for this reason that any kind of medium pruning is in such disfavour with a very large number of planters. The school

which favours making a clean sweep of everything by cutting right down to the ground is strongest in Upper Assam where not only is the climate relatively very favourable to this operation, but bushes thought to require it are generally in better condition than, for example, on a hot droughty exposed teela in the Surma Valley. Yet even in Upper Assam 10 per cent. of good bushes may be expected to be lost after collar-pruning, while the loss is very often 20 per cent., and in bad seasons 40 per cent. of deaths is not uncommon. On account of this possible heavy loss a very large number of men condemn collar-pruning altogether. Between these two extremes the truth lies.

Since a bush is entirely dependent on its leaves to provide food, a bush deprived of its leaves can only throw fresh shoots by drawing upon ready-formed reserve food material in its stems and roots. Until fresh leaves are formed the whole life-cycle ceases. The young fine rootlets of a collar-pruned bush die and have to be re-grown after a fresh food supply is established from new leaves grown out of reserves. Such reserves are naturally greater in a medium-pruned than in a collar-pruned bush, and in consequence the number of deaths after medium pruning is very small indeed, both because a larger amount of stem means a larger amount of reserve food in the bush, and because from the thinner wood left, new shoots will more readily arise.

The more good clean wood which can be left on a bush, therefore, the better, but no branches carrying disease must be left, otherwise disease will spread to the sound parts of the bush. Neither is the presence of hollowed, knotted or otherwise damaged wood desirable in a bush which is to be renovated. To remove everything undesirable of this nature often does mean that the bush must be practically collar-pruned. There are however cases where only the top has become attacked by diseases, or where it is desired simply to reduce the height of a sound bush to allow more convenient plucking. In such cases it is often possible to leave a good frame composed of sound branches, by cutting the bush across at a convenient height and removing only a little unsound wood below that height.

When cutting back the reduction of the height of the bush is always a consideration, and for that reason it is hardly sound to make the cut any higher than about 18 inches or the bush will too soon be over-high again. On many bushes a cut at 18 inches would leave little more than a single stump which is most undesirable. It is not worth while to medium prune unless something of a frame is left, and for this reason, also, the only method of cutting back a bush may be practically to collar-prune it.

In practice then, either because there is no frame sufficiently near the ground or because the frame is composed almost entirely of diseased branches, the only sound method of cutting back a section is often very nearly to collar-prune most of the bushes. It is urged however that whenever there is a chance of preserving a good sound frame, it should not be neglected.

To cut a bush to the collar leaving nothing, when some good clean branches might have been left, is a serious error, because the percentage of deaths is unnecessarily raised. Particularly is this so when fine young shoots near the collar might have been left, so that one could get the advantage of removing the whole of the old wood while leaving shoots to ensure that the plants will live, and come away much more quickly and strongly than if no shoots had been left. If there are no such shoots then older thicker wood may often be left, so long as it is sound. From such branches shoots will arise much quicker than from the stump, even if the branch is so cut down that no leaf remains on it, but it is of course an advantage to leave leaf if possible.

When such "Kickers" are left there is a tendency for them to become attacked by red spider and other diseases. It is therefore sound to cut these away, or down to good wood, after they have done their work, that is when new shoots have arisen from the stump. In leaving "Kickers," also, care should be taken that if they are strong then kickers should be left on each side of a stump, or a one-sided bush may be grown, and that side of the stump from which no shoots arise will rot, and

eventually so will the whole bush. If only one strong kicker is left, it must be cut away very early.

Both opposite opinions (1) that tea should never be collar-pruned, and (2) that collar-pruning is the only satisfactory method of cutting back, contain germs of truth, but both err in going to extremes. Every individual bush should be treated on its merits, but in practice it is necessary to give a fairly simple order.

If it is decided that there are frames worth saving, then an order may be given to cut down to the particular height which suits the average bush best, with the proviso that all diseased branches must be removed cleanly, while some few bushes may have to be collar-pruned.

If it is decided that it is necessary to cut right down, then that order may be qualified by ordering that young shoots or good branches from near the collar must be left. Both jobs require good supervision, but it is remarkable how soon good coolies grasp the principles, and apply them.

In addition to the points already referred to a few others may be briefly mentioned.

Leaving Shoots.

As far as possible one should aim at the avoidance of snags. If a branch can be removed flush with a shoot, however poor the shoot may be, the remaining wood is preserved from death by the flow of sap induced by the presence of the shoot ; and if the shoot or a new one arising just under it, can be induced to grow with sufficient vigour, then the cut (if made cleanly) will callus over, and leave no wound to be infected. When a cut at a certain height is ordered, it is always worth while to make the cut a little higher or a little lower if by so doing a shoot can be left.

Knots.

If there is a knot in the branch, a new shoot often arises from the knot nearest to the cut. For this reason many planters are in favour of making the cuts through knots, and in that case

a large number of new shoots do arise from the top of the cut shoot. The knot however is a very hard thick piece of wood, and a clean cut through it is very difficult to make. A cut through a knot also is difficult to heal even with a shoot to help it, neither is a shoot from a cut knot usually as good as a shoot from straight wood or even as a shoot from the next lower knot. It is probably better therefore to attempt to cut below knots, and to try to leave straight wood.

Protection of Wounds.

The chief cause of trouble after cutting back is the entry of fungus diseases after cutting back. Tar, and fungicides such as Bordeaux paste, have been used to prevent entry of disease at the cut surface. Unless, however, a shoot arises close to the cut, the wood is bound to die back to the next shoot, and disease will eventually attack the dead snag. The only perfect protection is a natural callus growth over the wound, and this can only be obtained if a shoot arises near a clean cut on a vigorous bush. The vigorous bush must be obtained by previous soil treatment and by sparing plucking.

The difficulty, of course, is to get the shoot to arise near the cut. On old hide-bound stems, particularly if cut before a dry spell, the highest new shoot generally comes away some distance below the cut, leaving the wood above the shoot to die. If, however, the shoot will not come at the cut, the cut can always be made at the shoot after a shoot has grown. The second cut is best made by going over the pruning a second time as soon as shoots have come away after the first cutting back. This of course greatly increases the labour of pruning but it is better to do a small area well, than a large area badly.

If however the snags are left for one year only, little harm is done, but tea after medium pruning should never be left unpruned, unless the snags are first removed either immediately after cutting back, or at the end of the year following the cutting back.

In the case of a cut right down to the ground, the cut is automatically made very close to the place where new shoots will arise, and therefore if the stump comes away quickly it will always start to callus. Shoots from collar-pruned bushes however are often very slow in coming, and meanwhile the exposed stump dries, bark cracks away from it, and the wood starts to die back. Disease then enters, and even though shoots arise from lower down, the life of that bush is often a short one. The higher the stump is out of the ground, the more likely it is that shoots will arise from it, but it is also more likely that they will arise below a piece of dead wood which will become diseased.

Shoots arise much less readily from roots than from stems. It is therefore not sound to fork away soil before cutting and cut through the root itself, but if half an inch of stem is left it is sufficient on an old stump. The cut will then be about at ground level where the bark will be kept moist by the soil, and after the stump has come away it will become covered by soil, which will assist the continued growth of the protective callus, by keeping it moist, while the layer of soil is itself a protection against fungus attack. Stumps cut to the ground and lightly covered with soil usually callus well, and throw good shoots also particularly in sandy soils.

Shoots however do arise more freely if the stump is exposed by forking away the soil. This forking is often overdone and then results in drying not only of the stump but of the roots also. Only an inch or so of stump should be exposed at most. In this case the cut bark is exposed to drying. It will however callus splendidly under a paste, of fresh cattle manure with a little soil, spread over the cut, particular attention being paid to the covering of the cut bark. This paste may be applied also with advantage to cuts on thick branches.

It is hardly necessary to remark that cuts should be made as smooth as possible, to give them the best chance of callusing over. Because, once upon a time, daos were used for heavy pruning, it cannot be argued that the nature of the cut is of no

importance. Kukris are still occasionally used with success for collar-pruning, but the instruments are sharp and the men skilled in their use.

For cutting to the collar or for heavy branches, a sharp saw is the best instrument, and it should leave the bark unbroken at the edges. The practice of bevelling the edges of a saw cut with a knife is a bad one. The wood, above the level to which the bark is cut, is almost certain to die and to hinder callus formation.

Preparation for Cutting Back.

If cutting back is to fulfil its purpose of replacing old and diseased branches by vigorous new ones, the bush must be got into vigorously growing condition before it is cut down.

No treatment, of course, can cause dead wood to throw new shoots, nor will treatment produce good shoots from branches so diseased that they ought to be cut away ; but treatment should be able to produce good shoots at least from the parts of bush which will be left after heavy pruning.

If a bush is so weak as to carry no good shoots, then to heavy prune it will only further weaken it. The cutting back of such a bush should be postponed till it is in better condition. If treatment applied with this object is found to make heavy pruning unnecessary, all the better ; but at any rate such cultivation, manuring, and sparing in plucking must be applied as will bring the bush into condition to come away well after cutting back. Neglect in these respects before the cutting, cannot be atoned for by good treatment after the bush is cut-back. It is clear that a bush cannot take advantage of raw material in the soil, if it has few leaves or none to manufacture it into plant food. A cut-back plant can only take advantage of good after-treatment when sufficient leaves have been grown out of reserves produced in the bush before it was cut down. There are, for examples, cases on record where a section has been cattle-manured and a part cut down immediately afterwards which came away

much less well than another part carrying similar tea which was cut down a year after the manure had been applied.

Manuring before Cutting Back.

As regards manuring 20 tons of cattle manure per acre, a year before cutting back, is an ideal preparation, and one that is usually sufficient by itself. Failing that, a mixture of artificials to suit the soil combined with green cropping may be used.

The very common method of relying on a single standing green crop to be trenched in, in alternate lines, is not a good one. The tea is too liable to suffer in vitality, even if only temporarily, from the presence of too dense a crop of green manure for so long, and the cutting of the roots by trenching also introduces another possible cause for loss of vitality. To cut down and trench at the same time is particularly objectionable, since the bush is then damaged at both ends at the same time ; but a weak bush may not recover from trenching even after a year. Nor is it desirable to bury all the manure on one side of a bush only. If high growing crops which occupy the soil for a year are preferred, then it would be better to sow the first green crop 4 years before cutting down is intended, trench in the first crop three years before cutting back, sow another crop on the trenched lines, and trench in the second crop two years before cutting back. For the year before cutting back a complete mixture may be used. Unless however there is a definite mechanical obstruction in the soil which is hindering growth, deep trenching is not recommended for tea to be cut back, although shallow trenches may be used as convenient for burying green crops.

It is of course impossible to lay down rules for the amount of manuring necessary before cutting down. If after one year's treatment the condition of the tea still appears too poor, then treatment should be continued.

Plucking and Pruning before Cutting Back.

If the frame is to be cut away there is no object in spending money and time on expensive pruning. To leave the bush unpruned however may be to expose it to such a strain as will

weaken it. A good system in general is merely to cut across without any cleaning out at all. The wood left, also, may be rather longer than is usual on ordinary top-pruned tea. A good crop will then be obtained, without undue exhaustion of the bush, if it is in good health.

In the case of a bush which is to be cut down because it is weak, or becoming weak, it should naturally not be exhausted by any attempt to get a large crop before cutting down. No rules, of course, can be suggested, but plucking should be lighter according as the bush is weaker, and in extreme cases it is advisable to leave weak bushes unplucked altogether.

Soil Treatment after Cutting Back.

When tea prices are good, it pays to manure any tea every year. Whatever prices may be, however, it is essential that a cut-back bush should be fed, while it is rebuilding its frame. No rules applicable to all soils can be given, but manuring must vary according to the soil. Complete mixtures accompanied by green manuring are required. While "pruning mixtures" should nearly always provide potash and phosphoric acid, it is unsound to rely on these only. Nitrogen also is necessary to produce good stems and leaves to feed them.

Cultivation also must not be neglected. This is an important matter when considering the advisability of cutting back. While bushes which provide good cover may keep fit on three or four rounds of light hoeing, such treatment on a cut-back area may ruin the tea by letting it go under jungle.

One or two rounds of forking around the collar will be necessary, while if light hoeing is relied upon to keep down jungle when it is growing vigorously, a hoe as often as every three weeks may be advisable until the bush is big enough to provide cover.

If increased expenditure on cultivation and manuring cannot be afforded, then cutting back should be postponed until it can.

Collar-pruned areas on suitable land however are particularly suitable for buffalo-cultivators.

Plucking after Cutting Back.

Expenditure on cultivation and manuring may be reduced if cut-back bushes are allowed to grow unplucked, or plucked very lightly until they provide sufficient cover to keep down jungle. The crop lost from cut-back tea by plucking lightly, or even not at all, cannot be very considerable, while no other treatment can have such good effects on the bush.

Collar-pruned tea (if very vigorous) may be plucked to 27 inches, or sometimes even 24 inches, from the ground, without much harm if it is to be pruned again in the following year. Thirty inches or even 36 inches is often much better on weak tea, in the latter case plucking being only sufficient to hold back over-vigorous shoots.

It is uncommon to find collar-pruned bushes over-plucked, because to do so would mean plucking inconveniently near the ground, but it is very often the case that the only reason why medium-pruned tea is unsuccessful is that it was over-plucked after cutting back. Much of course depends upon the vigour of the bush, but in our opinion a cut-back bush of good jat very rarely should be plucked to leave less than 12 inches of new growth above the pruning cut (which on a bush pruned to 18 inches from the ground means plucking at 30 inches from the ground), while plucking in no case should be nearer to the ground than 27 inches.

Pruning after Cutting Back.

After cutting back, pruning has of course to be directed to the building of a strong frame of reasonably wide spread, but the chief consideration must be the avoidance of diseased wood in the bush.

The year after cutting back is the time when good pruning is of the greatest importance.

Whether the tea was medium pruned, or collar pruned with Kickers left, new shoots will have arisen in many cases some distance below the cuts and hence will have dead snags above them.

It is at this stage that it pays, after cutting at the height ordered, to get at the bush with knives and small saws to cut out every bit of dead or diseased wood flush with a sound shoot.

This pruning is far more important than the original cutting back, for nothing but sound wood should remain after it. The old wood should in every case be left protected by a shoot growing from its top, and the new one-year wood should also as far as possible be cut to an eye. Such a bush very easily can be kept free from dead wood throughout its future history.

Because it is necessary to clean up a bush as soon as possible after cutting back, tea should never be left unpruned the year after cutting back, unless either the original cut was flush with the ground leaving nothing, or the original heavy pruning was gone over again to remove snags after shoots had come away.

When the bush has been thoroughly cleaned up and has had two years' of light plucking, it should be vigorous enough to be left unpruned without fear, with the double object of getting a good crop and of leaving leaves to feed up a strong low frame. If left unpruned, the bush must be cleaned up again very carefully at the next pruning. For example the following rotation of pruning would be good one, though it is by no means suggested as a standard to suit all cases.

First Year. Cut-back.

Second Year. Pruned leaving 4 inches to 10 inches new wood (according to height of original cut), and all dead and diseased wood removed.

If less than 4 inches new wood, thick after generous growth, is left, the new shoot is very likely to arise from the base of the new wood leaving a lot to be cut out at the next pruning.

On low cut tea more wood will naturally be left. Opinions on how much wood should be left after collar-pruning vary between 5 inches and 12 inches above the collar. The lower the cut, the wider will be the spread near

the ground, while the higher the cut the greater will be the immediate crop, the less die back there will be, and such dead wood as occurs is more easily cut out in the following year.

In our opinion about 8 inches is generally most satisfactory, but it may be lower on thin wood which has grown nearly perpendicularly, and higher on wood which is very thick and well inclined outwards.

Third Year. Unpruned, if bushes are thoroughly fit.

Fourth Year. Pruned 3 inches to 6 inches above last pruning cut, and all snags carefully cut out flush with a branch.

Here, again, very short wood should not be left, or new shoots may arise from the junction of the 2nd-year wood and the 3rd-year branch, forming a knot.

Fifth Year. Pruned as appears to suit bush best.

Sixth Year. Unpruned.

METEOROLOGICAL OBSERVATIONS IN THE DOOARS, 1925.

By C. R. Harler.

Plant Disease and the Weather.

Of recent years the study of plant disease has had an increasing tendency to take into account not only the pest or blight itself but also the host. It is becoming more and more evident that strong plants are able to throw off disease attack and that an attack by an insect or fungus which succeeds in killing or seriously incapacitating a plant may be taken as a sign of weakness in the plant. Some seasons may be more favourable to the development of a certain disease than others and during these seasons the plant will suffer more, especially if weather favourable to the disease is unfavourable to the host.

In the cultivation of tea as in other branches of agriculture it is noticed that diseases suddenly appear, do more or less damage and then disappear. The disease is present always but suddenly becomes epidemic and then some factor changes, conditions become unfavourable to the disease and its ravages are reduced to negligible proportions.

A few years ago Thread blight became serious in tea gardens in Assam but now it is rare. In 1922 and 1923, Black rot, a spicies of Corticium, attacked the stems of tea bushes. Spraying with lime-sulphur was resorted to and the disease ceased to be a menace, although it is probable that a change in some factor, probably one beyond control, had more to do with the lifting of the attack than had the spraying. During the seasons 1924 and 1925 another species of corticium, as yet unnamed, put in an appearance although as soon as it became epidemic planters remembered having observed it in a sporadic form for many years.

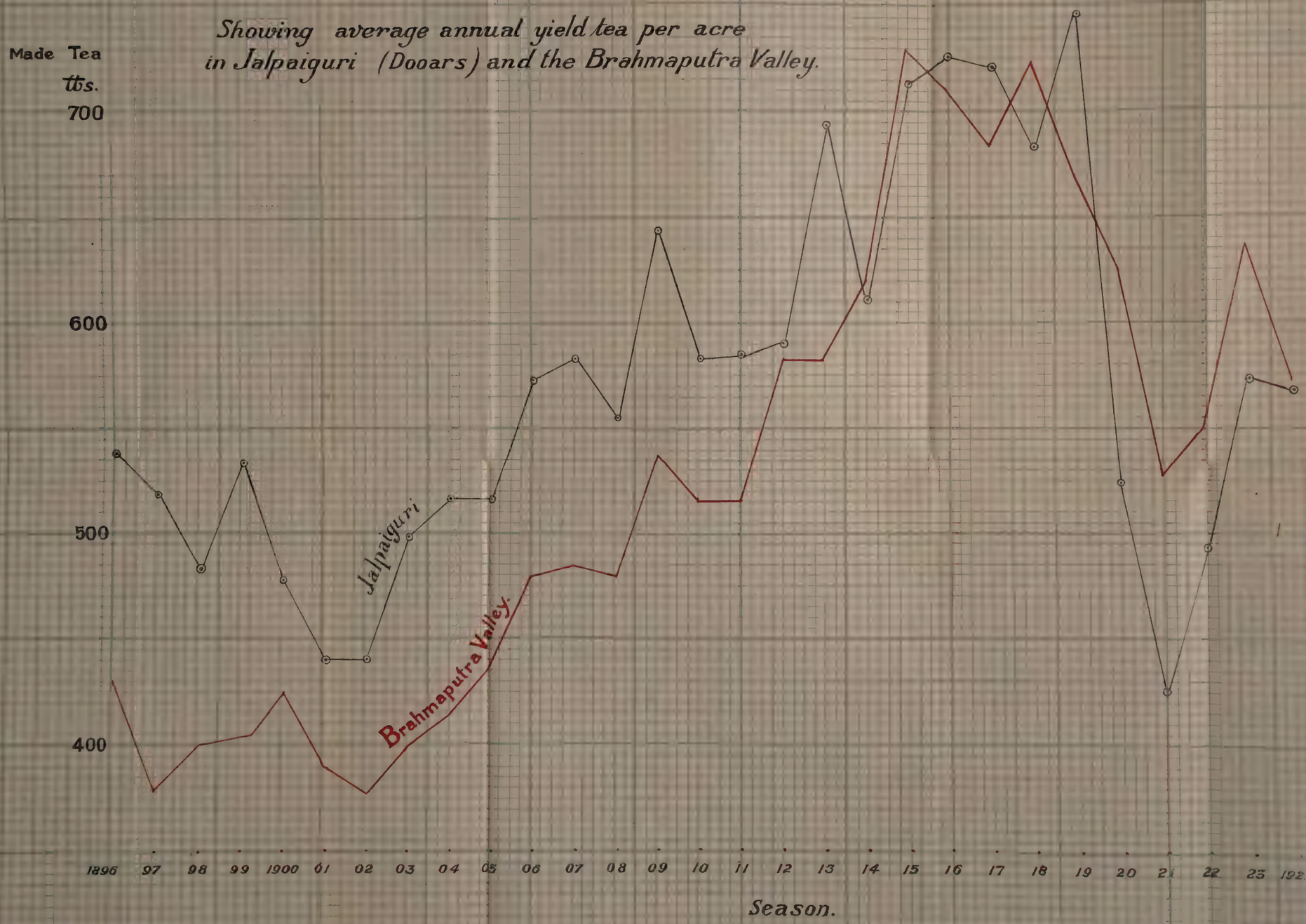
Diseases come and go naturally but spraying does much to control them. It has been observed at Tocklai that although spraying lessens Red spider the actual attack ceases at the same time on both sprayed and unsprayed areas. It is important to remember however that the coffee leaf disease (*Hemelia vastatrix*) of Ceylon came and remained to blot out the coffee industry in the Island in a decade or so.

Many gardens are now suffering badly from root disease, especially *Sphaerostilbe repens*. This may be partly accounted for by the fact that the years 1920 and 1921 following immediately on the slump were years of reduced cultivation and a general falling off all round in the quality of garden work. The seasons 1922, 1923 and 1924 opened with severe droughts. The result of all these factors was a bush so weakened that it easily succumbed to fungus diseases ever present in the soil. The soil had not suddenly become " sick " but the bush had gradually weakened. A strong bush can often throw off disease and for this reason systematic manuring, good cultivation and careful pruning to a great extent obviate the necessity of the use of fungicides and insecticides.

It is difficult to trace exactly which climatic factors increase or decrease disease attack since so little is known of the environment influencing disease. It is known that temperatures much above 75°F are fatal to Blister blight (*Exobasidium vexans*) and the coming and going of this blight is thus, in a sense, understood but little is known of the general conditions favouring any diseases and further knowledge will be available only after many accurate field observations. Results obtained in the laboratory do not always hold in the field where conditions are much more complicated. In the laboratory every factor is under control.

In studying weather conditions in connection with plant disease, climatic extremes tell us more than means, for life is influenced by extreme weather conditions and not by average temperatures and humidities. Thus the

Showing average annual yield tea per acre in Jalpaiguri (Dooars) and the Brahmaputra Valley.



average temperature of Darjeeling is only 2°F above that of London but the vegetation of the two places is very different. Darjeeling is subject to a different range of temperature from that experienced in London and palm and pine are able to grow there side by side.

An average value suppresses much and the average of a particular season gives no indication as to the peculiarities of that season. The annual average rainfall gives no idea as to the variation from year to year. In tropical countries it may be said that the annual rainfall varies much more than in temperature regions. At Tocklai with an average of 81 inches of rain the past eight years have shown totals as low as 66 and as high as 101 inches. At Sylee in the Dooars with an average of 164 inches a similar period has shown variations between 113 and 204 inches. This variability of rainfall may be measured by expressing the difference between the greatest and least annual rainfall as a percentage of the average. Thus at Tocklai the variability of rainfall is

$$\left(\frac{\text{Max.} - \text{Min.}}{\text{Average}}\right) \times 100 = \left(\frac{101 - 66}{81}\right) \times 100 = 43\%$$

At Sylee where greater variation is experienced the value is 55 per cent. In the Terai the value rises to 62 per cent. and in parts of Behar to 108 per cent. The variation in crop then, due to variation in climate, will be greater generally in the Dooars than in Assam.

The curves opposite show the crop in pounds made tea per acre of plucking area from the year 1896 to 1924 in the Jalpaiguri district (Dooars) and in the Brahmaputra Valley. The values are taken from Government returns. The curves are reproduced with the object of estimating roughly how much of the crop variation is due to climatic changes and how much due to other causes. In the Dooars the main cause of annual fluctuation of crop, other than the weather, is the severity or otherwise of mosquito attack.

It will be observed first of all that from 1900 to 1920 there was, in general, a steady crop increase due partly to improved methods and manuring, partly to coarser plucking and partly to the maturing of large areas of tea. The Brahmaputra Valley with a much lower crop than the Dooars gradually increased in outturn till both areas were about the same from 1915 to 1919. At the beginning of this period the tea in North-East India was in better fettle than it had ever been before. The years 1920 and 1921 following on the post-war slump were years of fine plucking and heavy pruning. During the next four years plucking became somewhat coarser as the market became stable but it is doubtful, even with the free plucking employed during the war years, whether the tea in its present condition is capable of touching the same output as during 1915-1919. Towards the end of the War period the rate of manuring fell off on most gardens and the big crops in these years were undoubtedly taken at the expense of the plants' reserves. The better treatment accorded to the bushes from 1922 onwards has done much to repair the earlier damage.

A detailed examination of the curve yields much information. In the Brahmaputra Valley the tea mosquito (*Helopeltis theivora*) does no appreciable damage and crop increases or decreases apart from the steady general increase is due mainly to seasonal variations. In 1898 and 1900 the Dooars crop fell whilst that in Assam rose. From 1902 to 1906 there was a continuous crop rise in Assam but the rise in the Dooars during this period was broken in 1905 when the crop was the same as in the previous year. In 1908 there was a slight drop in Assam and a much greater one in the Dooars. The same thing occurred again in 1910. Whilst allowing for the depredations of mosquito it must be realised that when the crop falls in both districts at the same time then the chances are that the cause is similar. In Assam the cause is generally assumed to be the weather and indeed crop depression in the Assam Valley can be closely correlated with this factor although the ultimate cause may be some unrecorded disease. In the Dooars there is a tendency

not to allow the climatic factor its full influence in controlling crop and to attribute a much greater percentage of the crop variation to mosquito attack than is justifiable.

The years 1910, 1911, 1912 were poor ones in the Dooars compared with the big year of 1909. The crop rose sharply in 1912 in Assam but not in the Dooars although in spite of this the years 1910-12 were certainly not ones of general decrease.

In 1913 the Dooars went well ahead again only to fall back in 1914 whilst Assam showed an increase in the same year. From 1915 to 1919 the crop averaged over 9 maunds an acre and only in 1918 did the Dooars show an appreciable drop during this period. Since 1919 the issue has been confused on account of crop control.

The curve relates of course to the Dooars as a whole and variations in the crop of local areas are thus masked. The year 1918 is reckoned in some districts to have been one of the worst mosquito years known but although the crop certainly shows a fall it is still much above 1909, a record year at that period, and not much in default of the 1913 crop, another record year.

Some years have been admittedly bad with mosquito but others like the present season (1925) have been fairly free although the crop has been in default.

The figures for 1925 show the Dooars crop to be about 590 lbs. and the Assam crop about 650 lbs. per acre. Thus the average crop is now back to what it was about a decade ago although the plucking nowadays is finer than it was then.

The 1925 Season in the Dooars.

The Drought Period.

The 1925 season started well, for the bushes were not hard pushed by the drought. The table below gives the dates of the last and first satisfactory falls, *i.e.*, falls of about an inch or more, over the past few years. During the early months of the year a fall of much less than an inch seems to aggravate the effect of the drought for the

soil is only penetrated to a depth of two or three inches and the mulch is destroyed.

Table showing Drought Period at Sylee.

Cold Weather.	Last Rainfall.	First Rainfall.
1916-17	October 17th	March 21st
1917-18	,, 8th	,, 28th
1918-19	,, 13th	,, 4th
1919-20	,, 8th	,, 23rd
1920-21	,, 28th	,, 9th
1921-22	,, 10th	,, 9th
1922-23	November 4th	,, 28th
1923-24	,, 13th	April 28th
1924-25	,, 7th	,, 6th

In October 1924, rainfall amounting to 20.42 inches was registered against an average for this month of 7.49 inches. In November of the same year 3.50 inches fell against an average of 0.98 inches. In December, January, February and March one or two showers were registered amounting to 0.20 inches, a negligible quantity.

At the beginning of April the bushes were looking healthy with the spring flush but the relative humidity was down in the neighbourhood of 40 per cent. and had not rain come when it did the effect of the drought would have soon been apparent. On the night of April 5th the rain came quite unexpectedly, and from that date till the end of October precipitation was continuous and on 20 days only was there no rain.

Although the first falls during April were intensely local the relative humidity rose from about 50 per cent. to 80 per cent. with the first rain, proportionately decreasing the loss of soil moisture by evaporation and transpiration from the leaves. Although some gardens did not get rain till the middle of April they benefited from the damp air flow which came at the beginning of the month.

In April 118 hours of bright sunshine were recorded, mostly in the first 20 days.

The Monsoon.

There was no break between the early rains and the Monsoon, and in May 37.50 inches were registered against an average of 11.08 inches for this month. Hail was rare. During May there were 101 hours of bright sunshine, evenly distributed.

The advance of the Monsoon in June was anything but spectacular for its advent was marked only by a sharp rise in the vapour pressure from 0.80 to 0.90 inches and an increase in minimum temperatures from about 75° to 79°F. In June, 124 hours of bright sunshine were registered and the distribution was good.

In July rainfall was in defect of the average but a steady drizzle persisted during the second half of the month and the sunshine only amounted to 94 hours, more than 60 of which were recorded in the first fortnight.

August was the wettest month of the season and 41.04 inches fell against an average of 28.01 inches. The total bright sunshine amounted to 96 hours but this was unevenly distributed and in the middle of the month rain was incessant. During the first six days of the month, 36 hours of sunshine was registered but during the next 14 days only 18 hours were registered.

In September 32.84 inches of rain fell and during the third week of the month 14 inches were recorded. Up to the 22nd of September Monsoon condition prevailed but two days later the whole weather aspect had changed and the atmosphere became dryer. Although two big falls were registered after this date the air still remained dry and the vapour pressure fell from about 0.92 to 0.84 inches of mercury and the relative humidity from 90 to 80 per cent. The total sunshine for September was 86 hours, again badly distributed.

The sharp drop in humidity together with low night temperatures made for an early close to the season. The Monsoon was not a strong one for the steady south-west breeze was never firmly established for any length of time and much of the rain came from the north by reflection from the hills.

Below is given the monthly rainfall for Sylee and the average values taken over the past ten years.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Average (10 yrs.)	0·47	0·74	1·12	3·99	11·09	33·43	44·56	28·21	28·07	7·49	0·98	0·19
1925	0·04	0·12	0·14	15·87	21·63	28·55	33·12	41·04	32·84	9·10	1·05	*nil.*

The average total is 164.48 inches and the total for 1925 is 181.50 inches.

It is of interest to note the difference between the sunshine in the Dooars and at Tocklai. The Table below shows the values during the 1925 season over the months April to September during which period Dooars records are available.

Table showing average daily Sunshine in hours during 1925.

	April.	May.	June	July.	August.	September
Dooars ...	3·9	3·3	4·1	3·0	3·1	2·9
Tocklai ...	3·5	3·3	5·2	5·1	4·4	3·9

Green Crops

The continuous rain right from the arrival of the Chota Barsat in April has been considered by some planters to be largely responsible for failure of most green crops throughout the Dooars during the season under discussion.

When putting out green crops it is preferable to sow a small acreage daily over a month or six weeks rather than the whole area in a few days. The former arrangement not only ensures that some of the crop shall be sown at the most favourable period, but simplifies the hoeing in of the crop.

Pests and Blights.

During April and May, Red spider was bad. It advanced in two waves and the bushes which escaped the first and less severe attack in April succumbed to the second in May. In spite of the heavy rain

this pest persisted. Blocks which had been sprayed with lime-sulphur, liberally sulphured or carefully cleaned out at pruning remained comparatively free from attack. After an attack of Red spider the bushes should be lightly plucked.

In June green fly came. The gardens on sandy soils seemed to suffer most. It is interesting to notice that in August a second green fly attack was reported and although the bushes had the "tucked up" appearance associated with the incidence of this pest, practically no green fly was to be found.

Towards the middle of June, mosquito attack began over large areas but after a week of fine weather the bushes got away again. The attack as a matter of fact showed up during the lull between the May and July flushes. From June onwards the attack was always noticeable, sometimes markedly, just after plucking, and at other times, with a flush on the bush not so easily.

In August mosquito descended in full force on some areas and the bushes took on the dark, shiny appearance peculiar to this form of pest attack. Brown blight on the stems, Grey blight, Corticium and Red rust were by this time present on the majority of attacked bushes but some were observed to be free from these blights and these bushes generally flushed again. The season ended quickly before the bushes had time to recover from mosquito.

The Soil Condition.

Just before the first rain the soil moisture at Sylee (a Mal Sand) and Nedeem (Red Bank) showed as follows :—

	Sylee.	Nedeem.
at 6 ins.	2·7%	21·0%
18" „ 2 ft.	5·7%	23·1%
30" „ 3 ft.	10·0%	23·3%

In spite of the fact that the Sylee soil was so dry the bushes were flushing vigorously. With rain the soil moisture rose to about 15 per cent. in Sylee and 25 per cent. in Nedeem. These values are about the optimum for both soils and were roughly maintained throughout the season.

It required about three weeks of steady rain amounting to over 10 inches before the sub-soil became thoroughly wet and reached the condition which was maintained during the Monsoon.

The table showing moisture values illustrates :—

Date.	April 5th.	April 13th.	April 20th.	April 27th.	May 4th.
Total Rainfall to date ...	*nil*	2·71″	5·22″	8·82″	16·97″
Sylee No. 10, top soil ...	3·2%	13·5%	12·5%	14·8%	14·4%
„ „ 10, at 2 ft. ...	5·5%	9·6%	13·9%	16·7%	16·5%
„ „ 10, „ 3 ft. ...	7·0%	7·0%	12·7%	16·1%	15·9%

Date.	April 5th	April 16th.	April 23rd.	April 30th.	May 7th.
Total Rainfall to date ...	*nil*	5·10″	7·36″	15·87″	18·71″
Nedeem No. 8, top soil ...	21·0%	22·3%	25·3%	25·9%	25·5%
„ „ 8, at 2 ft. ...	23·1%	22·5%	26·0%	29·0%	29·1%
„ „ 8, „ 3 ft. ...	23·3%	25·5%	23·0%	30·0%	29·0%

A weekly estimation of the soil nitrates on both soils showed that after the rains had set in in April the value fell from about 5 parts to about 0.05 parts nitrates per million parts of soil, and remained at that figure till the end of September.

The Weather Chart for 1925.

The accompanying chart shows the rainfall, the crop curves for Sylee and Nedeem and the maximum and minimum temperatures recorded on the bungalow verandah at Sylee. The latter figures are not comparable with temperatures taken under the standard conditions laid down by the Meteorological Department of India* which require that the maximum and minimum thermometers shall be kept in a white, louvred box of special design placed in the open, three feet above the ground.

*Instructions to Observers of the Indian Meteorological Department.

SEASON 1925

JANUARY 4 11 18 25 | FEBRUARY 1 8 15 22 | MARCH 1 8 15 22 29 | APRIL 5 12 19 26 | MAY 3 10 17 24 31 | JUNE 7 14 21 28 | JULY 5 12 19 26 | AUGUST 2 9 16 23 30 | SEPTEMBER 6 13 20 27 | OCTOBER 4 11 18 25 | NOVEMBER 1 8 15 22 29 | DECEMBER 6 13 20 27

SOIL MOISTURE
30%
20%
10%

SOIL MOISTURE

NEDEEM No.5.

SYLEE No 10.

CROP

CROP
1000 M/S LEAF
800"
600"
400"
200"
0"

SYLEE
NEDEEM

VAPOUR PRESSURE
1·00 INS MERCURY
0·90"
0·80"
0·70"
0·60"
0·50"

VAPOUR PRESSURE

TEMPERATURE
100°F
90°
80°
70°
60°
50°
40°

MAXIMUM TEMPERATURE

MINIMUM TEMPERATURE

RAINFALL
12 INS
10 "
8 "
6 "
4 "
2 "
0 "

RAINFALL

OBSERVATIONS MADE AT SYLEE TEA ESTATE.

Temperatures taken under such conditions are generally lower than those shown by bungalow readings.

The top soil moistures of Sylee No. 10 and Nedeem No. 5 are shown over a period of six months during which time very little change is noted. The Nedeem soil is a Red Bank clay with a greater water holding capacity than the Mal sand at Sylee.

The crop curves show that the tea came away sooner at Sylee than at Nedeem as might be expected. A sand is usually earlier than a clay except in the case of a severe drought. After Nedeem started to yield the form of its crop curve was much the same as that of Sylee.

The vapour pressures curve is shown for six months. The values are obtained from the readings of the wet and dry bulb thermometers taken at 8 A.M. and the actual vapour pressure figures are calculated from tables.*

Vapour pressure or humidity is the controlling factor in deciding the tea crop. The indigenous tea bush is constructed to live in a hot, humid climate and its leaves are designed so that they are able to transpire freely. The leaves of China bushes are slightly differently made from those of Assam and Burma bushes and the China jat is able to withstand the drought and cold better than the other varieties. At Ranchi, where dry weather conditions are extreme, only China bushes will grow successfully. In Japan where the atmosphere is quite humid but the cold weather severe, China bushes are again the only successful ones. In Chittagong, South Sylhet and the Terai, all three districts liable to pfolonged droughts, indigenous bushes are noticeably "thinner" than in Assam where low humidity is seldom a matter for worry.

Humidity also has a great influence on the quality of the tea made. Since high humidity makes for good crops it follows that when the crop is heaviest the possibilities of good withering will be reduced, so that a rush of leaf generally coincides

* Tables for the Reduction of Meteorological Observation in India by Simpson & Walker, Government of India Meteorological Department.

with a fall in quality of the tea for reasons not only attributable to factory limitations. In most Dooars gardens there are hot air withering lofts which give a certain amount of control over the wither but the greatest use is seldom made of such lofts. In Assam the number of days on which a natural wither is possible is greater than in the Dooars but some scheme of control is still necessary although at present lofts are rarely used.

In the fermenting room a high humidity is necessary in order that good colours shall be obtained. It is noticed that the best colours are obtained on wet days and that better colours are obtained in the morning than in the afternoon when the air is dryer.

IMPORTANT POINTS IN TEA MANUFACTURE.

Part II.

BY

P. H. Carpenter and C. R. Harler.

Fermentation.

The Fermenting Room.

The fermenting room should be cool and damp. The temperature of the room by no means controls that of the ferment, but it undoubtedly has a large influence on it, and should be kept at 82°F. or lower if possible. This temperature represents a practical maximum in the plains during the hot weather.

Light, so far as can be seen, has but little influence on the course of fermentation but it has become customary to keep fermenting rooms dark. This usually ensures a lower temperature in the room. It is not considered desirable that the fermenting room should be so dark as to make supervision of work difficult. Direct sunlight or direct reflection from the overhead sky is to be avoided.

The floor of the fermenting room is best made of good cement. A lime cement, being alkaline, should be avoided for alkalinity gives dark colours. Although experiments have been made in order to test which is better, glass or cement beds, and the results generally have shown no practical difference between the teas fermented on either, still the general opinion is that it is easier to make good tea on cement than on glass.

The fermenting floor can be kept clean by washing with cold water and no accumulation of slime should be allowed. Particular care should be taken with the cleaning of the floor and as soon as any unpleasant or unrecognised odour is noticed in the room, the floor should be thoroughly washed and scrubbed with cold water and if this does not affect the removal of the smell then a dilute solution of permanganate of potash should

be used. On no account should lime water or washing soda be used for this purpose since these solutions, if not completely removed by the final washings with water, will produce bad colours.

The floor should contain no corners, crevices, nor cracks capable of harbouring old leaves or tea juice. In order to facilitate the keeping clean of the floor there should be no raised nor sunk parts as beds for the leaf. Pillars in the fermenting floor should be avoided if possible since here again are angles where harmful bacteria can accumulate. A distinct camber on the floor is an advantage both as an aid to washing and also since it obviates the necessity of a definite channel to carry off any drip-water used for cooling and humidifying purposes.

The use of iron shovels in the fermenting room is to be discouraged, not that their use will appreciably alter the value of the tea but this is one of the many small points which together go to make up a measurable difference in quality.

The atmosphere in the fermenting room should be as humid as possible. The amount of moisture in the atmosphere or the degree of humidity is measured by the wet and dry bulb thermometers. These two thermometers are identical in structure except that one (the wet bulb) has the bulb surrounded by a piece of muslin kept wet by means of a wick coming from a small bottle of water. As the water on the muslin evaporates so the wet bulb is cooled. The dry bulb thermometer registers the air temperature. It will be seen that the dryer the atmosphere the quicker will the muslin round the wet bulb dry and, in consequence, the lower will be the temperature registered by this bulb. The difference then between the wet and the dry bulb will be a measure of the drying power of the air and this is actually a measure of the moisture in the air. If the difference between the two bulbs is *nil*, then the atmosphere is saturated. In this case no drying of the muslin has taken place and the relative humidity is 100 per cent. A difference of 1°F. between the two bulbs represents a relative humidity of about 95 per cent. working at the average fermenting room temperature.

In the fermenting room a difference of not more than 1°F. between the wet and dry bulb should be aimed at although this degree of humidity is difficult to obtain. With a fermenting room placed on the north side of the factory, fitted with a good double ceiling and hung with wet cloths both round the perforated walls and as baffles, a high degree of humidity is possible.

Some factories have installed humidifiers similar to those used in Cotton Mills. These humidifiers force water under high pressure through a fine jet and the result is a cloud of water vapour. A cheap, makeshift humidifier may be constructed as follows. The lance and nozzle of an ordinary Knapsack sprayer is placed downwards in the centre of a cylinder of metal about 10 inches in diameter and 18 inches long. Water at about 100 lbs. pressure is forced through the nozzle and the result is a very fair imitation of the spray produced by a humidifier. Some of the spray collects as drops which may be caught by a cone placed below the cylinder and carried off in a pipe. A little adjustment of this simple apparatus to suit local requirements will produce a machine capable of raising the humidity of the fermenting room to 100 per cent. Head space of about 15 feet is necessary otherwise the area over which the machine produces an effect is much reduced.

The influence of humidifiers on colours is discussed later but it must be mentioned that as the air becomes loaded with water vapour so the temperature falls. How far the good colours are due to high humidity and how far to low temperatures has not yet been estimated.

Spreading and Time.

The thickness of spreading of the fermenting leaf and the time of fermentation are factors which should be considered together. To a large extent the fermentation process may be regarded as an oxidation process which is hastened both by temperature and also by the amount of oxygen (*i.e.* air) available.

As the fermentation proceeds, briskness or pungency gives way to flatness and at the same time strength is gathered. We

are thus faced with the problem of staying the loss of briskness or pungency whilst the tea has time to take on strength. This may, in a way, be achieved by thickening the spreading which in effect reduces the air supply and slows up certain chemical reactions connected with loss of briskness. If the spreading is thicker than about 5 inches then there is a danger that the air supply will be so reduced and the chemical reactions proceed so slowly that the tea remains green. On the other hand when the reactions do proceed there is a danger with thick spreading that the heat developed will not be able to escape. The result is a rise in temperature and a consequent hastening of the chemical reactions. The problem is thus a complicated one.

One way out of the difficulty is to spread thinly—about 2½ inches—and to put wet cloths over the ferment. The air supply is thereby restricted and at the same time the leaf does not get hot. At the end of the season when lower air temperatures are experienced the time of fermentation must be lengthened or the spreading thickened, or both. As an alternative the air supply may be increased, *i.e.*, the spreading may be thinner, provided the atmosphere of the fermenting room is humid.

The temperature of the fermenting leaf should be as near 82°F. (or lower) as possible when it is first put on the fermenting beds. If the leaf as it comes from the roller is put through an efficient ball breaker installed in a cool place, it will certainly cool to a low enough temperature. During fermentation the temperature rises to a maximum at which it remains for some time and then falls. The maximum temperature should not be above 86°F.

The time of fermentation must depend on the chemical state of the leaf when it leaves the withering racks. Quite apart from this, however, different gardens seem to produce leaf requiring different types of fermentation and experiments are needed on each individual garden. All experiments however must be carried out with forethought and care and only one factor should be varied in each experiment. Results must be interpreted with caution and each experiment must be pushed to a conclu-

sion. A pointed example may be quoted. At one factory the teas produced were weak and the suggestion was made to lengthen the time of fermentation. Three experiments were carried out with the leaf fermenting for 3, 3½, and 4 hours. The 3-hour tea was brisk and weak and valued at Re. 1/- (nominal). The 3½-hour tea was less brisk but stronger and valued at 14 annas whilst the 4-hour tea was still less brisk, but notably strong and valued at Re. 1/0/6. The second tea was mediocre with no stand out briskness or strength and thus the price was not intermediate between the other two but below them. If a single experiment only had been tried and the fermentation increased by half an hour the wrong conclusion might have been drawn.

Colour of infused leaf.

The colour of the infused leaf is important. The green colour often obtained may be due to an insufficient wither, not enough air in the fermenting leaf or a too short fermentation. Dark green colours are often the result of a dry breeze blowing on the leaf. Uneven colours result from insufficient ball breaking after the rolling process. A bright green infusion usually goes with a brisk tea and indicates underfermentation. Such teas when over-brisk are often called "raw" or "green." A dark green infusion goes with a flat tea and often denotes underwithering accompanied by over-fermentation.

Bright colours are obtained from fully withered leaf if the fermentation is a short one but it is easier to obtain good colours from leaf withered on the light side. Thin spreading, provided the atmosphere is humid and no drying of the leaf takes place, gives bright colours, but it may by reason of the plentiful air supply, push certain chemical changes to a conclusion before others have had time to develop sufficiently and the resulting tea may be soft.

Good results have been obtained by spreading thickly (to 4 inches) and turning the fermenting leaf each half hour. The best results have been obtained from leaf thinly spread in a cold, humid atmosphere.

The best colours are generally made in the morning when the temperature is low and the atmosphere humid. Poorer colours are made in the afternoon as the atmosphere gets dryer. In some factories all tea is manufactured at night for it is considered that the slacking off in efficiency which must arise with night work is more than compensated for by the lower temperatures and higher humidities pertaining at night.

The control of Fermentation.

If the temperature of the leaf is kept low and the atmosphere humid then the rate of oxidation going on during fermentation may be said to be proportional, within limits, to the air supply. This means that with the conditions regarding temperature and humidity ideal, a thin spread (good air supply) combined with a short fermentation should give the same results as a thicker spread with a longer fermentation.

This has been observed in the factory many times and the teas produced under the following conditions—

2½ inches spread	3¾ hours' fermentation.
3½ inches spread	4½ hours' fermentation.
5 inches spread	6 hours' fermentation.

were identical so far as the taster's report was concerned. No very definite figures can be given concerning the best fermentation conditions because so much depends on the degree of the wither. With a normal good wither, a cold rolling room (82°F.), and leaf in the fermenting room at 82°F., a fair average time of fermentation is 3½ hours if the leaf is spread at 2½ inches. At 73°F. it has been found that the time must be increased to 4½—4¾ hours and for intermediate temperatures the increase should be in proportion.

Firing.

From the chemical point of view firing merely means the cessation of chemical action in the leaf. The rate of fermentation increases with temperature so that unless the leaf meets a certain degree of heat on entering the dryer the fermentation is merely carried on at an increased rate and the tea may be

overfermented and lose briskness unless the necessary allowance is made in the time the leaf remains on the fermenting floor.

The temperature of the exhaust air of a pressure dryer, *i.e.*, the air which meets the leaf when it first enters the dryer, should be about 120°F. below the top tray. Theoretically the best temperature is 150°F. but with the ordinary dryer such an exhaust temperature would necessitate too high an initial temperature.

The first fire should be at least 12 annas otherwise the second fire must be carried out at a high temperature and the tea is liable to lose quality.

The firing temperature should be kept as low as 170°F. on forced draft machines. If the firing temperature is too low—below 140°F.—the tea will not keep, for the enzymes are not destroyed and fermentation continues. As the temperature of firing is increased so the tendency to produce poorer teas is increased. The higher the firing the less briskness and the less strength will be obtained in the final teas. High firing destroys the colour of tip.

In many factories firing is carried on at high temperature in order to cope with the leaf. In others it is often stated that a dryer will not function unless the initial temperature is at some figure far beyond the safety mark. In these latter cases the trouble generally lies with the fan which is too slow running. The capacity of a dryer is the product of the rate of air flow and the temperature of the air. It follows then that the capacity may be increased by speeding up the fan and leaving the temperature at its original figure. In several factories the fans are run at speeds somewhat in excess of the scheduled number of revolutions and good has always resulted from such increases.

A series of experiments were carried out on a Down Draft Dryer in order to investigate the temperature at which tea was high fired. This particular type of machine was used because

of the ease of control but the temperatures apply to any form of dryer.

Thus—

Tea fired to 16 annas at 170°F.	—	not high fired
Tea fired to 16 annas at 170°F then left at 170°F. for 15 mins.	—	not high fired
Tea fired to 16 annas at 210°F.	—	not high fired
Tea fired to 16 annas at 210°F. then left at 210°F. for 10 mins.	—	high fired
Tea fired to 16 annas at 240°F.	—	high fired
Tea fired at 170° and temp. raised to 240°F. by which time tea had dried to 14 annas Finished at 170°F.	—	not high fired

The conclusion is that tea cannot be high fired at 170°F. but that temperatures over 200°F. become dangerous if the tea remains for long at such temperatures. True, Empire machines with initial temperatures as high at 260°F. turn out tea which is not high fired but it must be remembered that the leaf on the bottom tray only is submitted to this temperature. Firing under such condition causes a loss of briskness and strength in the finished tea.

When leaf is fed into an empty dryer the first tea discharged is liable to be high fired, if the dryer is heated to much more than 200°F. In order to obviate this the side doors of the dryer should be left ajar till the first leaf is near the bottom trays.

Automatic temperature recorders are useful on drying machines. Although no very definite firing temperature can be given if tea is to be consistently turned out at 12 annas during the day a variation of 10°F. should cope with any variation in the moisture content of the leaf during the day's manufacture.

"Gaping" of Tea.

Tea when it is packed should contain 5 to 6 per cent. moisture. If it contains more it is liable to "go off" before it gets Home and if less, post-fermentation is restricted and the tea will not mellow and it

also loses pungency. When tea comes from the second dryer it contains 2-3 per cent. moisture but during sorting more is picked up, for tea is very hygroscopic, and the moisture increases to 7 or 8 per cent. In cases where much picking over for stalk is done the moisture figure may rise to 10-11 per cent. In several cases where complaints have been received that the tea does not keep well, examination has shown the moisture content to be between 7 and 8 per cent.

It is very difficult to tell by feel or smell whether tea contains the right amount of moisture for packing. Some factories have installed a chemical balance and a small steam oven and thus the moisture content of each bin is estimated before the tea is packed. The process of moisture determination is a simple one and the apparatus costs less than Rs. 200.

The unnecessary heating of tea causes loss in the quality of the liquor so that gaping should only be employed when it is necessary and even then it should be carried out at as low a temperature as possible. A temperature of 180°F. is sufficiently high.

Sorting.

The sorting of tea is so largely dependent upon market conditions that it is not proposed to deal with it here. There is, however, one point to which attention might be called. The "greying" of tea is brought about during sorting and cutting of the dry leaf and consists in polishing the surface of the tea. Any machine therefore that causes a rubbing of the surface of the leaf tends to produce greyness. Machines running at high speed by increasing the rubbing effect tend to increase the amount of greyness. In sorting therefore the type of machine used should be one that, so far as is practicable, does away with the rubbing of the leaf. The circular sifters running slowly consequently tend to grey the tea less than if they are speeded up but in any case they cause the rubbing action to take place. Other machines such as rotary sieves running at much higher speeds also give greyness to the tea. Machines which produce a hopping rather than sliding action on the sieves tend to grey

the tea less. Machines depending on an air-blast such as the deflector type of machine are the least liable to grey the teas. One cause for the greying of tea is the speed at which the cutters or breakers are run. A fast run machine will tend to grey the teas much more than one run slower, and consequently such machines should be run at the slowest speed that is compatible with efficiency. One often sees such machines run at too high a speed in order to get through the amount of work whereas what is really required is another machine so that the two machines may both work at proper speeds.

During the sorting tip is very easily destroyed, consequently to obtain a tippy finished tea it is necessary that the fine mal should be subjected to the very least possible amount of sorting and cutting.